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DATADIGIT SYSTEM

R. J. STATTEL
J. W. FENNEL, JR.

DECEMBER 1968

GSFC

— GODDARD SPACE FLIGHT CENTER —
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DATADIGIT SYSTEM

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Sounding Rocket Instrumentation Section

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ABSTRACT

The DataDigit System is a part of a pulse-position-modulation (PPM) telemetry system, used extensively for sounding rocket flights, and designed by Sounding Rocket Instrumentation Section of Goddard Space Flight Center. Time information, once-per-second, is printed in three Arabic numerals on analog paper records. Time source can be either a PPM Countdown Clock or a NASA 36-bit time code. Grid lines are provided to indicate the beginning of each second. Time written in this manner is much easier to read than the usual 100 pulse-per-second 36-bit code.

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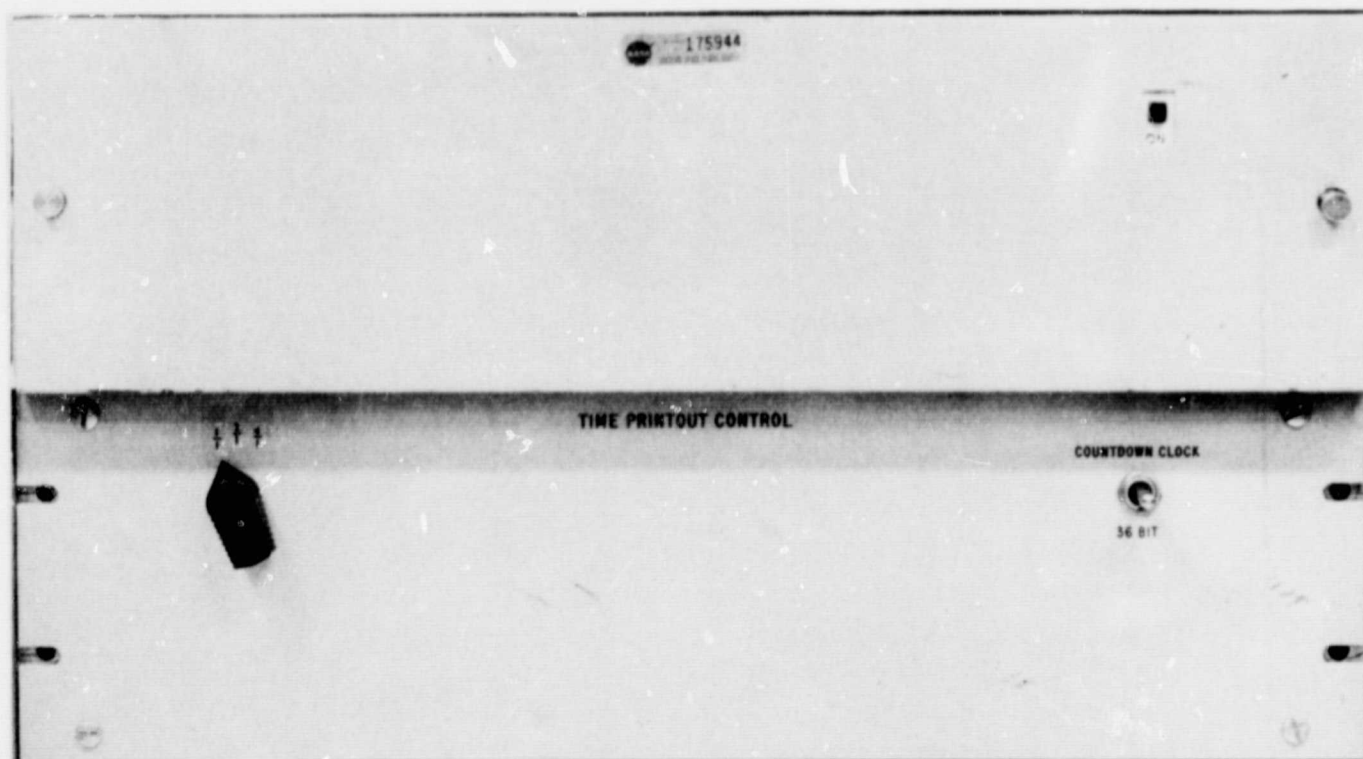
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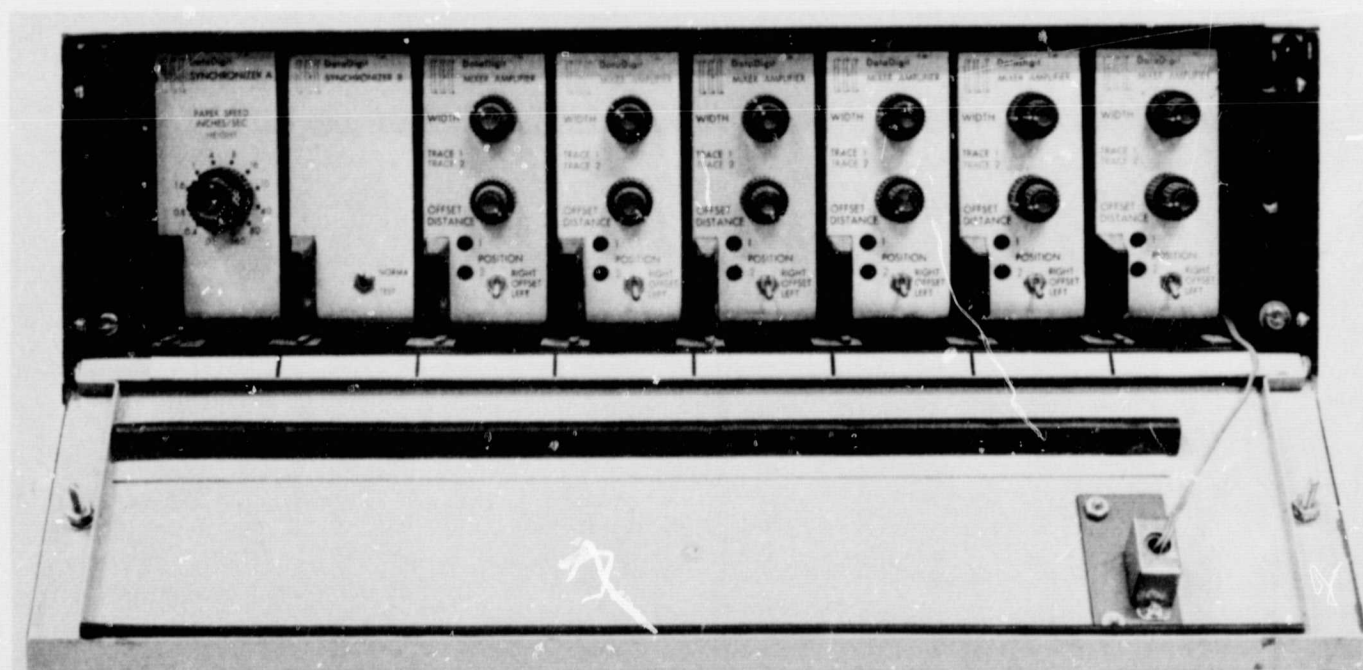
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Time Printout Control Unit



Data Digit Unit

Frontispiece — Data Digit System

DATA DIGIT SYSTEM

INTRODUCTION

The Sounding Rocket Instrumentation Section of Goddard Space Flight Center designed and implemented a pulse-position-modulation (PPM) telemetry system used extensively for sounding rocket flights. The system is used both for real-time missions in the field, and at the test or assembly station, where the experiments and rocket instrumentation are integrated and prepared for flight. Figure 1 shows a block diagram of the system.

The PPM telemetry system consists of two major systems: the airborne PPM system aboard the sounding rocket, and a PPM ground station system that receives and records the data transmitted by the airborne system. This report deals exclusively with the DataDigit System of the PPM ground station, and provides general functional and physical information, theory of operation, operating instructions, and maintenance procedures.

GENERAL INFORMATION

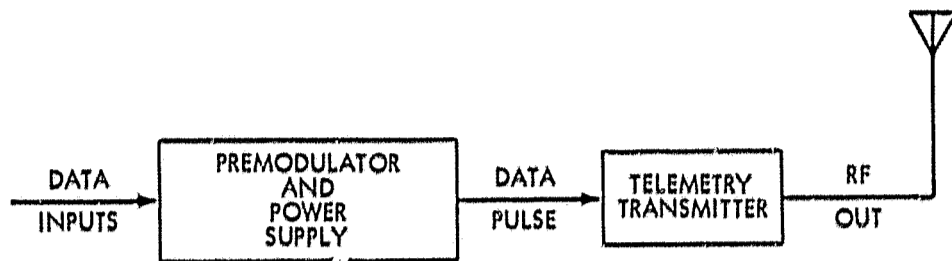
FUNCTIONAL DESCRIPTION

The DataDigit System was designed so that time from either of two sources, the NASA 36-bit time code or the countdown clock, could be printed in three Arabic numerals on analog paper records.

If the 36-bit time code is used, its source can be a Hyperion Time Code Generator or any recorded source; it must, however, be at dc levels (unmodulated). Provisions are made to accept recordings at one-half or one-quarter speed. If the countdown clock is used, signals must come directly from the clock. This proves useful during integration checks.

In addition to the numerals, oscillograph grid lines also occur on the indicated second (once every two seconds if using 36-bit at one-half speed). An example of the resultant printout is provided on Figure 2. Switches provide for constant numeral size, regardless of paper speed.

If the countdown clock is used as the time source, the three numerals represent seconds, ten second units, and hundred second units. If a 36-bit input is used, the first two numerals represent seconds (zero to 59) and the last represents units of minutes.



SST-3 TELEMETER

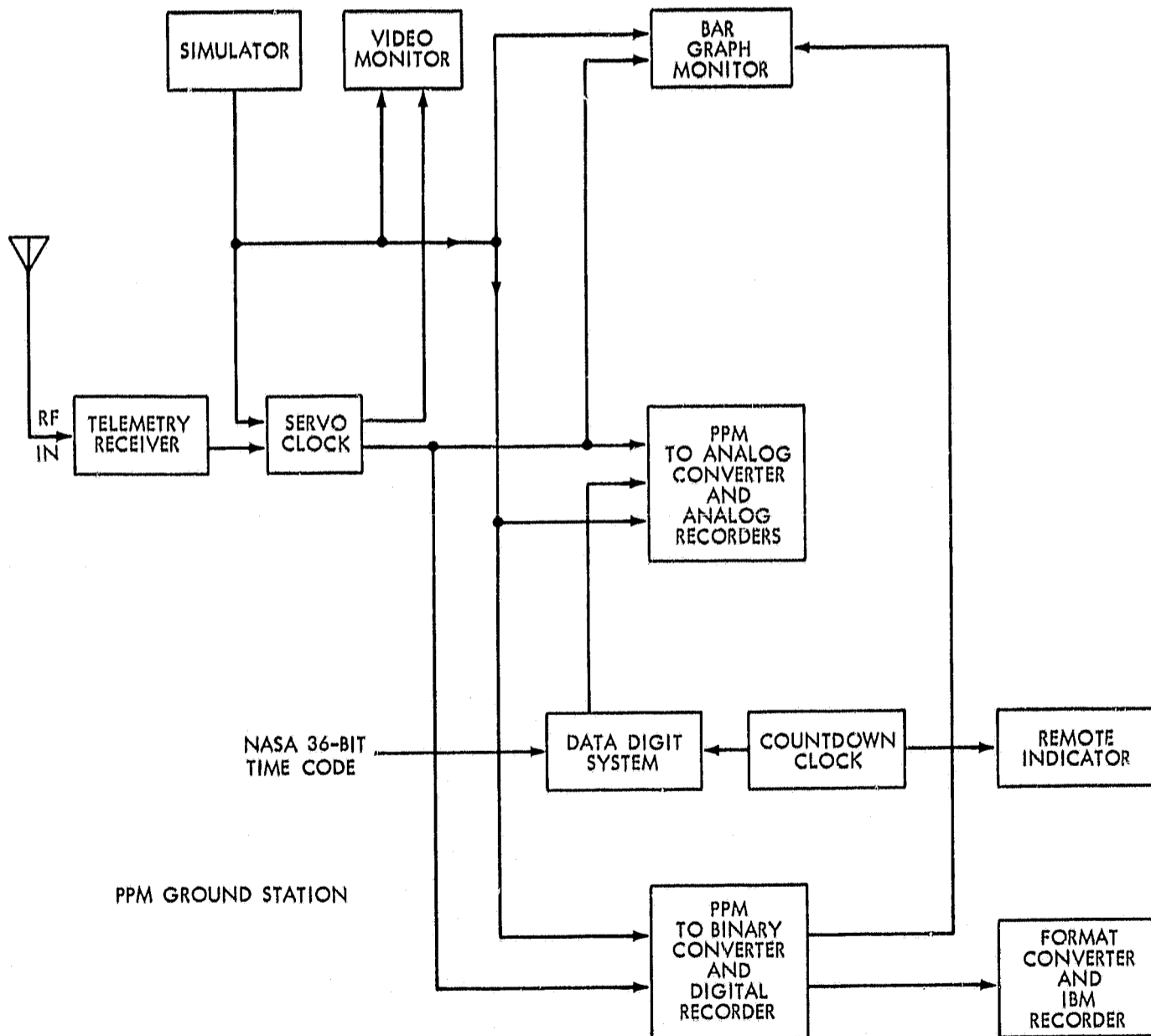


Figure 1. PPM Telemetry System, Functional Block Diagram

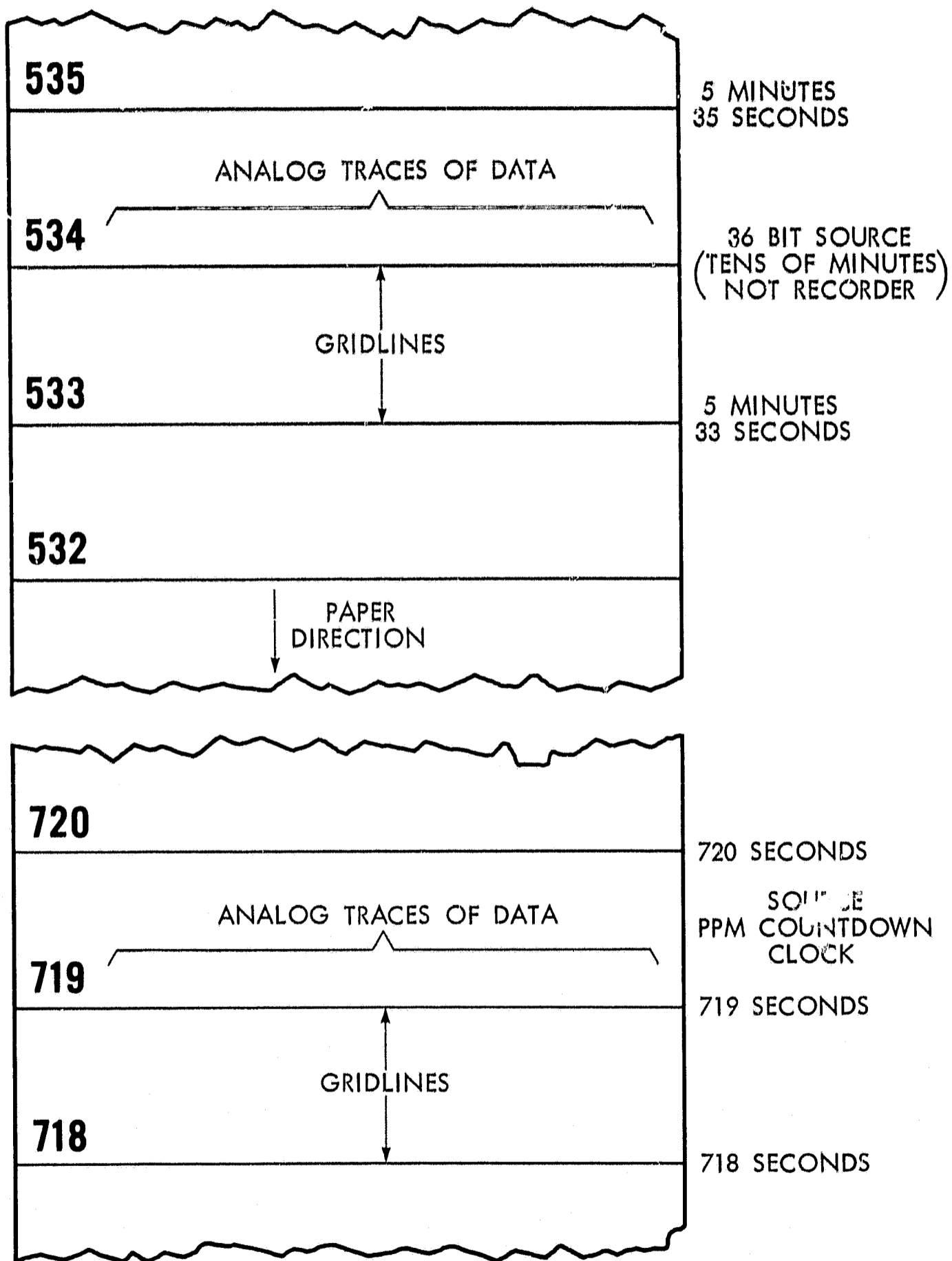


Figure 2. Example of Printout

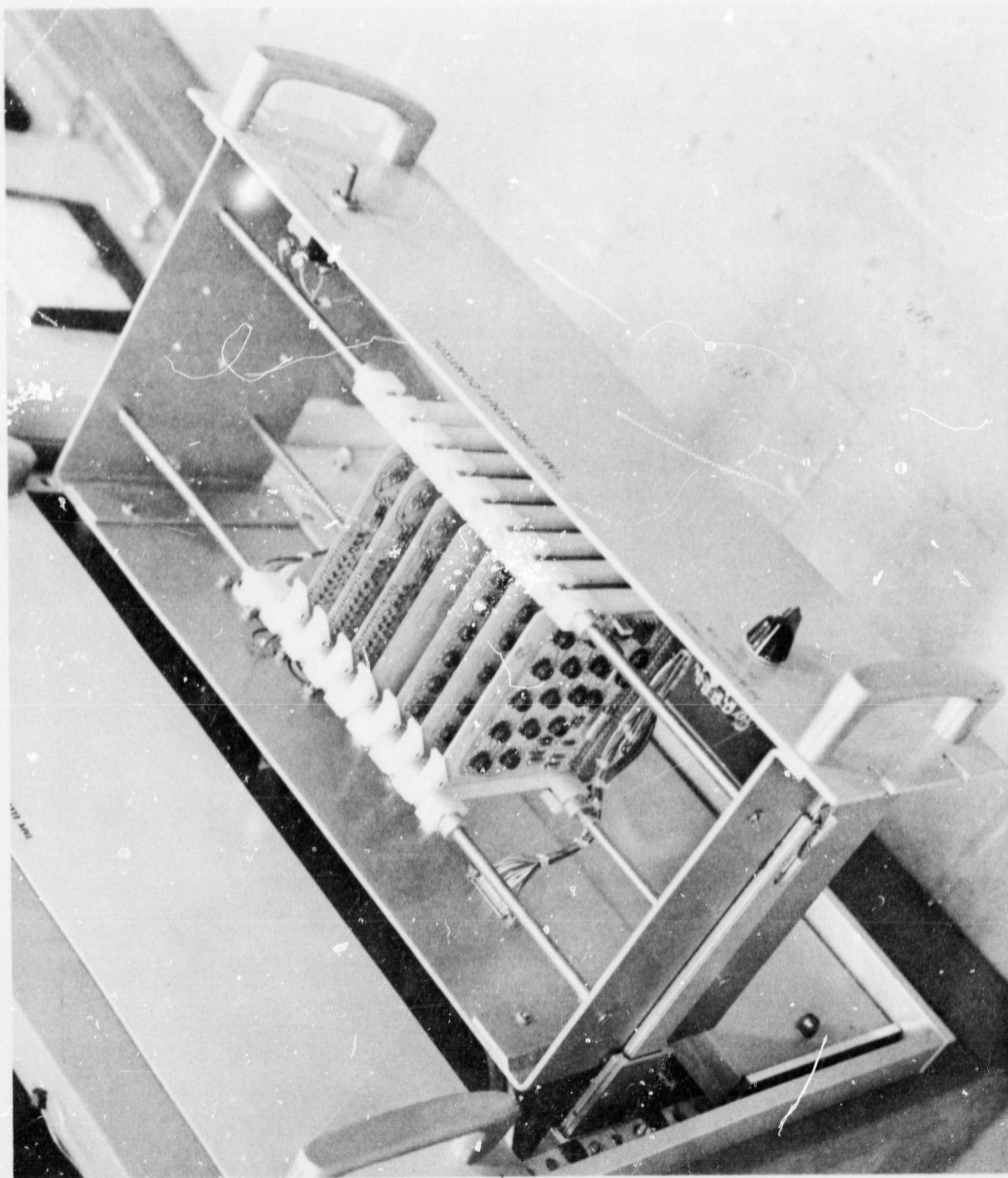


Figure 3. Time Printout Control Unit

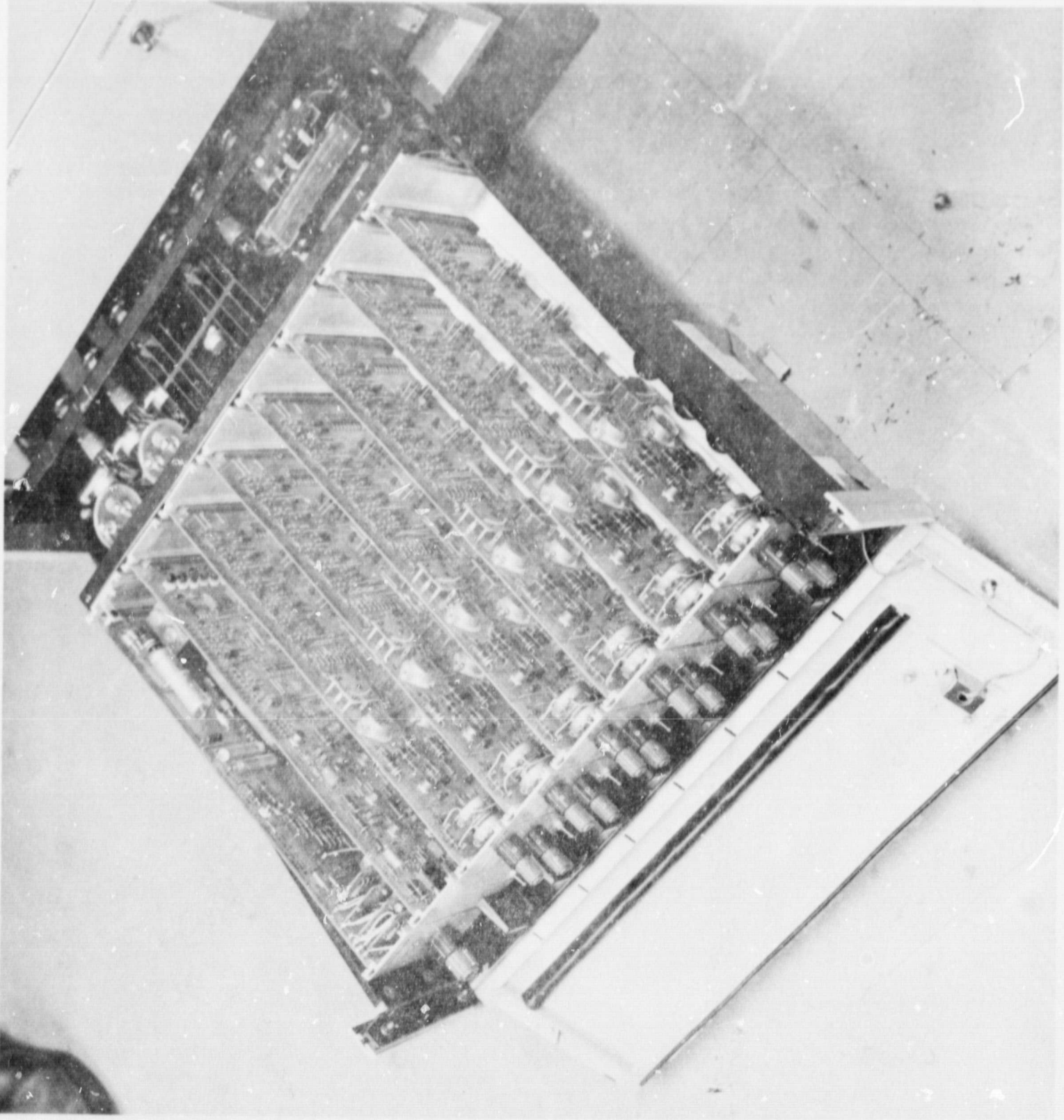


Figure 4. Character Generator

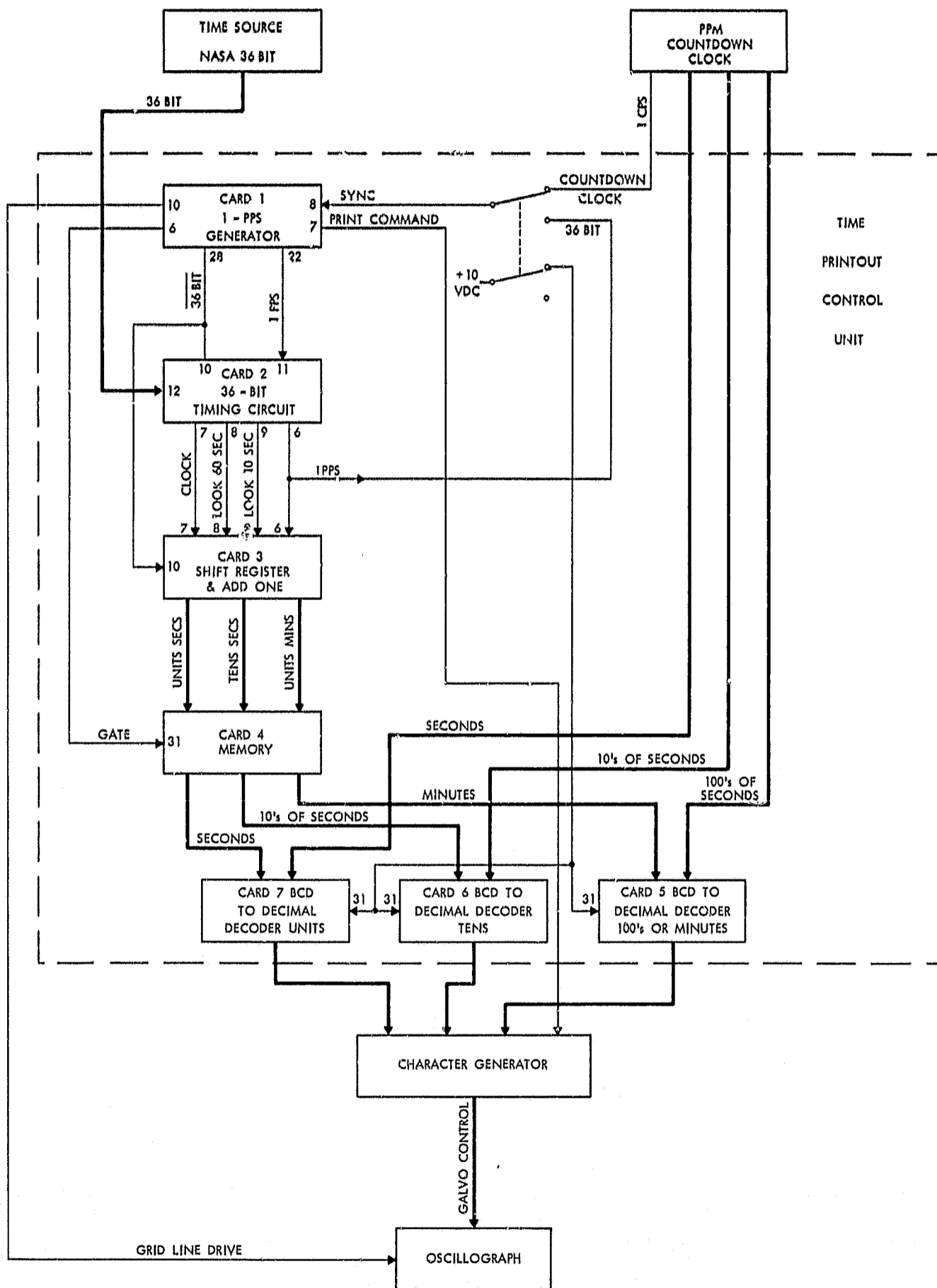


Figure 5. DataDigit System, Block Diagram

ratios of 1:1, 2:1, or 4:1. A switch on the front panel of the time-printout control unit allows selection of the input source. In addition to switching the data inputs of Cards 5, 6, and 7, the switch changes system synchronization to a pulse provided by the countdown clock, or the one pulse-per-second (1-PPS) derived by Cards 1 and 2 from 36-bit code.

If the countdown clock is used as the time source, parallel binary-coded-decimal (BCD) data indicating units, tens, and hundreds of seconds enter Cards 7, 6, and 5, respectively. These cards contain relays which are activated by the panel switch. The relays select data from, in this case, the countdown clock. Cards 5, 6, and 7 convert the BCD input, at logic voltage levels, to decimal code at 10 volt levels, at the output. The decimal code is required by the character generator. The system synchronization, now the synchronizing pulse from the countdown clock, enters Card 1. At the beginning of each second, Card 1 produces a pulse which drives the oscillograph grid lines. After a slight delay (1 millisecond), a print command goes to the character generator, causing it to release the three numbers presented to it by Cards 5, 6, and 7. The galvanometers on the oscillograph then write the numbers on the paper record. With the countdown clock as the time source, the memory card is not used.

After the recorded paper speed is correlated with the character generator, the height of the numbers can be controlled by settings on the character generator. Proper set-up of the character generator and of the oscillograph galvanometers is explained in the Operation section of this manual. (See page 20.)

If the NASA 36-bit code is chosen as the input source, it must be a dc, 10-volt, pulse-width modulated waveform. It can occur at speed ratios of 1:1, 1:2, or 1:4. The selector switch on the time-printout control unit must reflect the speed ratio used, and the panel switch must be set to 36-BIT.

Operation with the 36-bit input is as follows: Card 1 generates a one pulse-per-second synchronization pulse from the inverted 36-bit (36-bit) input from Card 2. This pulse synchronizes Card 2, which produces timing signals to select the proper information from the 36-bit code. Card 3 contains an adder, to add one second to the value presented by the 36-bit code. This addition is necessary since the time described by a frame of information is the correct time as of when that particular frame started. The complete frame is received one second after the time it is describing occurs. The time information, after the one is added, is stored in a shift register where any incorrect BCD numbers, which could result from the addition of one, are corrected. For example, if one was added to a BCD ten (consisting of eight and two), an incorrect BCD eleven would result. The correction process would correct the situation as described in the explanation of Card 3. (See page 12.)

Card 4, the memory card, accepts the useful information when the next memory gate pulse occurs. Cards 5, 6, and 7 are now presented inputs from the memory, Card 4. The BCD information is converted to decimal, and a print command causes the character generator to print the information. If the 36-bit input is one-half or one-fourth speed, the information is printed once every two seconds, or every four seconds, respectively.

The character generator provides signals necessary to drive the galvanometers of the oscillograph. Two galvanometers per character are necessary for each character to be printed.

Before operating the system, the character generator must be properly set up as described in the Operation section, (page 20) and in the CEC DataDigit manufacturer's manual. After adjustments are made, number size will remain constant if the paper-speed switch setting on the character generator agrees with the speed setting of the oscillograph.

TIME PRINTOUT CONTROL ELECTRONICS

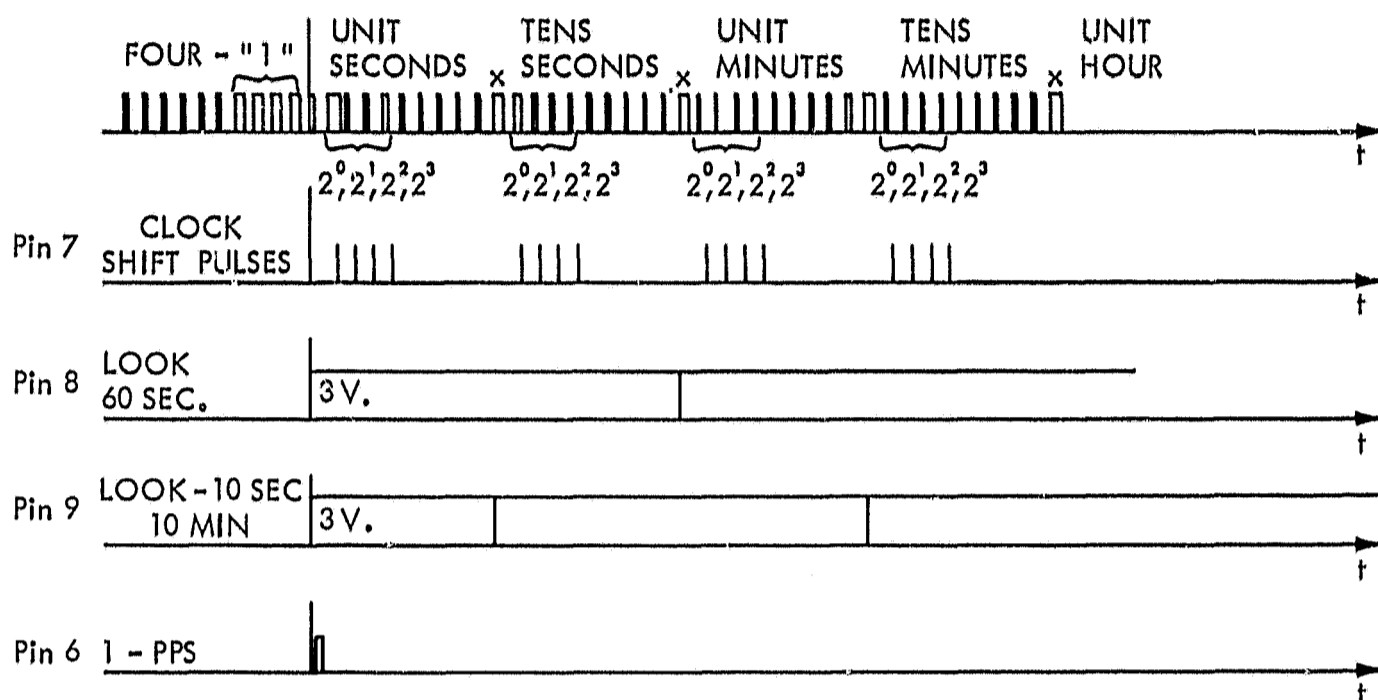
1-PPS GENERATOR, CARD 1. Card 1 generates a pulse to mark a frame of the 36-bit code. Flip-flops count the number of ONE bits in the code. Four ONES in succession can occur only once at the end of a frame. The first ZERO detected after four or more ONE bits begins the output pulse. It ends with the leading edge of the next pulse. Thus, a pulse occurring once-per-second, called 1-PPS, is generated at the beginning of each time code frame.

To determine if a pulse is a ONE or a ZERO, a comparison pulse is generated and compared with each input pulse. This comparison pulse is generated by two one-shot multivibrators. (See Figure 6.)

In cases where the 36-bit code is recorded and played back at one-half or one-fourth speed (10 or 20 kilohertz), the front panel switch must be set accordingly, thus changing the ZERO or ONE timing.

If desired, oscillograph grid lines can be driven by the system when external control is selected on the oscillograph. The grid lines will occur at the beginning of each second.

The leading edge of the system-synchronization pulse, which can be either the 1-PPS or the synchronization pulse from the countdown clock, fires a 1-millisecond delay circuit, which is used to drive the grid lines of the oscillograph after buffering on Card 1. The leading edge then fires a 1-microsecond delay circuit to enable the memory, followed by the 10-microsecond print command pulse for the character generator. Figure 7 is the schematic diagram of Card 1.



"0" - "1" RECOGNITION EXAMPLE

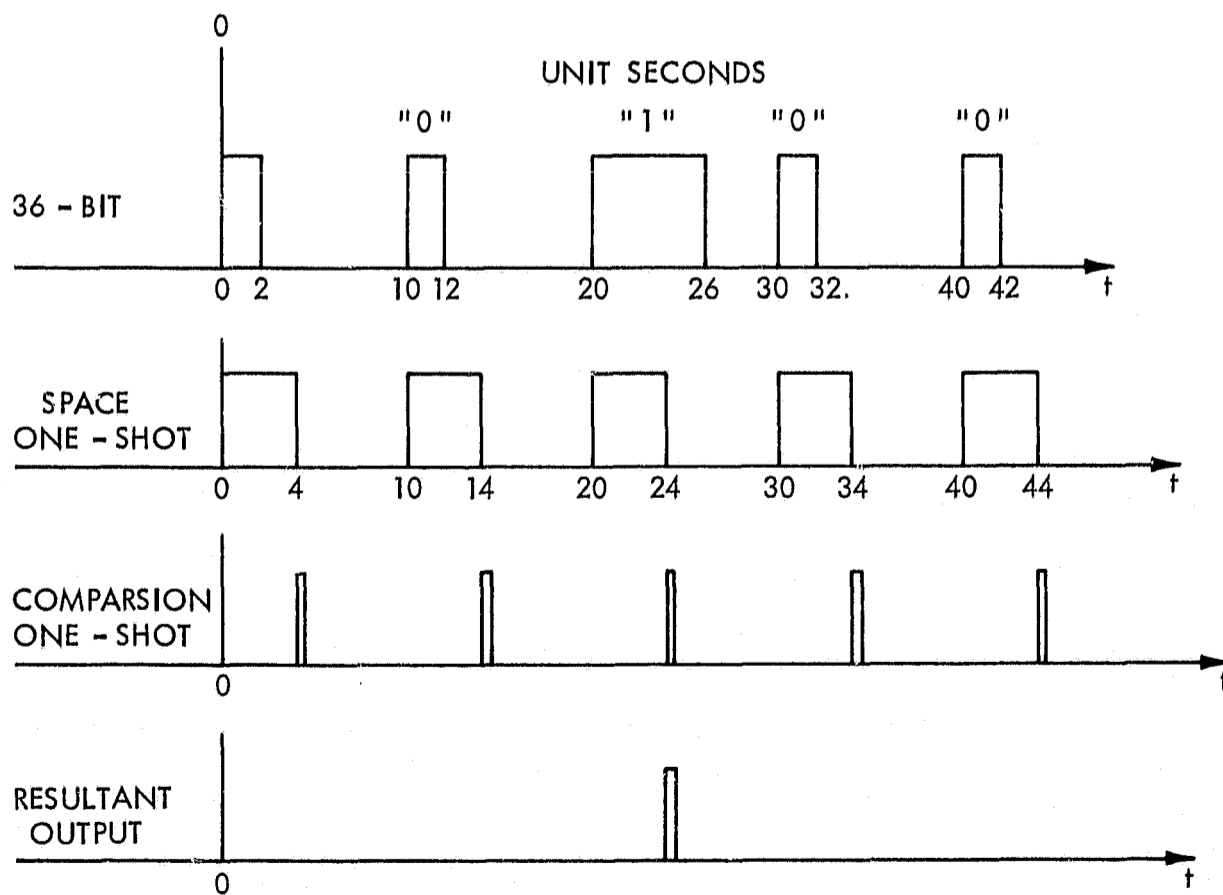


Figure 6. 36-Bit Code Timing Waveforms

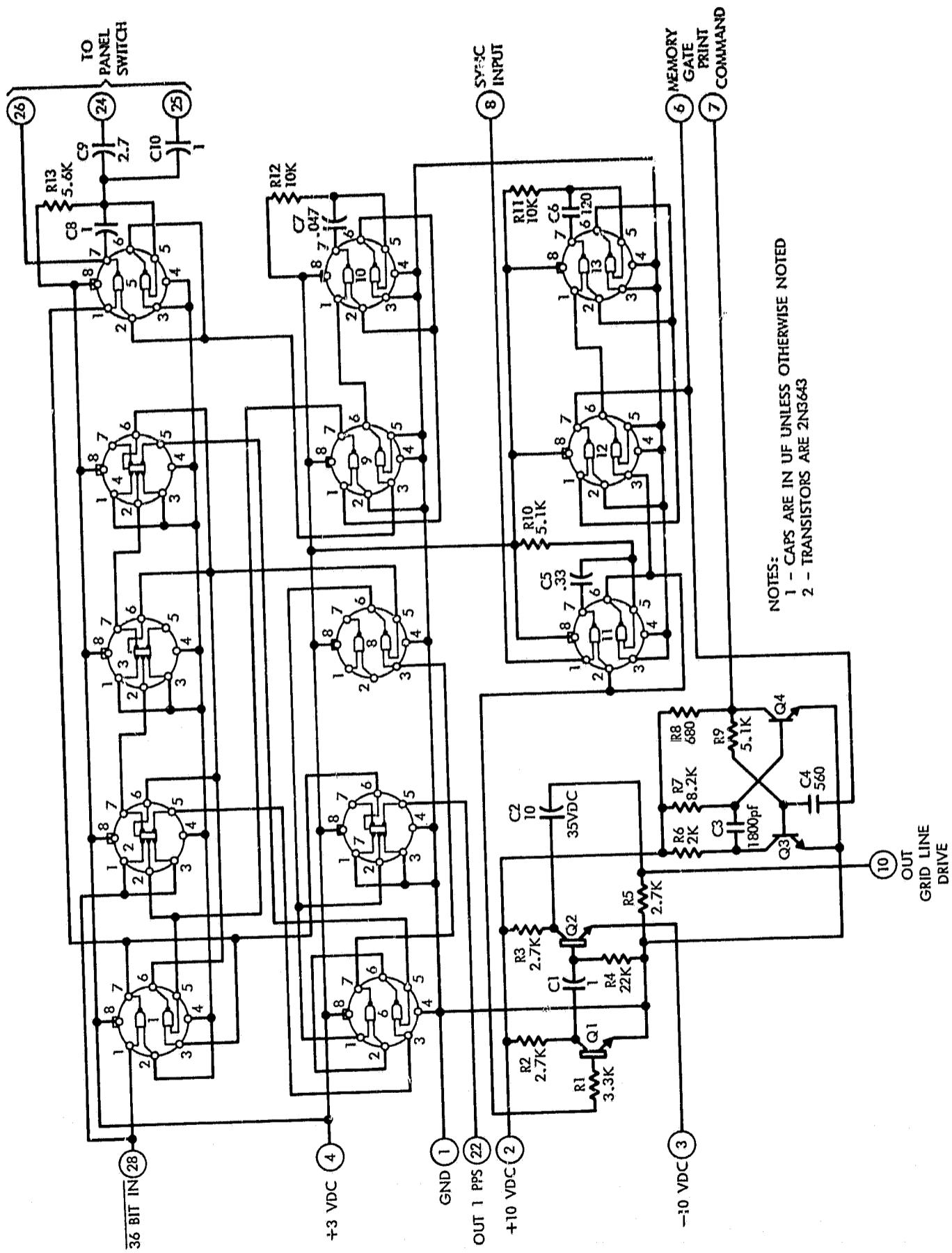


Figure 7. Card 1, Schematic Diagram

TIMING CIRCUIT FOR 36-BIT, CARD 2. As shown in Figure 6, the useful information in the 36-bit code is the first four bits of four ten-bit words. Counting-circuitry provides shift pulses (clock output shift pulses, pin 7) so that shift registers accept this useful information. The shift pulses are shown in Figure 6. Also, to correct the binary-coded decimal addition, pulses are provided to examine information stored in the shift register. These are: "Output look 10 second, 10 minute," (pin 9) and "Output look 60 second," pin 8, as shown in Figure 6.

If the time code is recorded and played back at one-half or one-fourth speed, timing circuit changes to correlate recorded speed with the character generator are made by a front panel switch. Figure 8 is the schematic diagram of Card 2, and Figure 9 presents a logic diagram of Cards 2 and 3.

SHIFT REGISTER, AND ADD ONE TO 36-BIT, CARD 3. Initially "In 1-PPS," pin 6, resets flip-flop A, so that ONE is added to the 36-bit input, pin 10. The sum is shifted into the register by the clock pulse and the clock pulse sets the flip-flop, removing the ONE. The carry is stored in the flip-flop B, and is added to the next 36-bit pulse and shifted into the register.

If the 36-bit input is 9, the BCD number 10, when formed by "8" and "2", must be removed. When the input is 9, the resultant 10 is detected by the AND gate, which is enabled by "Input look 10 second, 10 minute," pin 9. After the "8" and "2" are detected and removed, flip-flop A is reset to add "1" (weighted as ten) to the incoming tens-of-seconds. After the first bit of tens-of-seconds, the clock sets flip-flop A and removes the "1." After tens-of-seconds are shifted-in, the "Input look 60 second" pulse permits the circuit to verify the presence of 60 in the holding register. If 60 is present, "1" is added to units-minutes in the manner previously described, and seconds is set to zero. After unit-minutes, a check is performed to see if "8" and "2" are present; if so, "1" is added and tens-minutes is set to zero. After 16 clock pulses, the register is full, with the time updated by one second.

At the beginning of the next frame, the information in the register is transferred to the holding registers of the memory card. Figure 10 is the schematic diagram of Card 3, and Figure 9 is a logic diagram of this card, and of Card 2.

MEMORY CARD FOR 36-BIT, CARD 4. The memory consists of three 4-bit units. Information is stored for approximately 1 millisecond after the 1-PPS, by a 1-microsecond pulse. Both are provided by the printer control card. Figure 11, is the schematic diagram of Card 4.

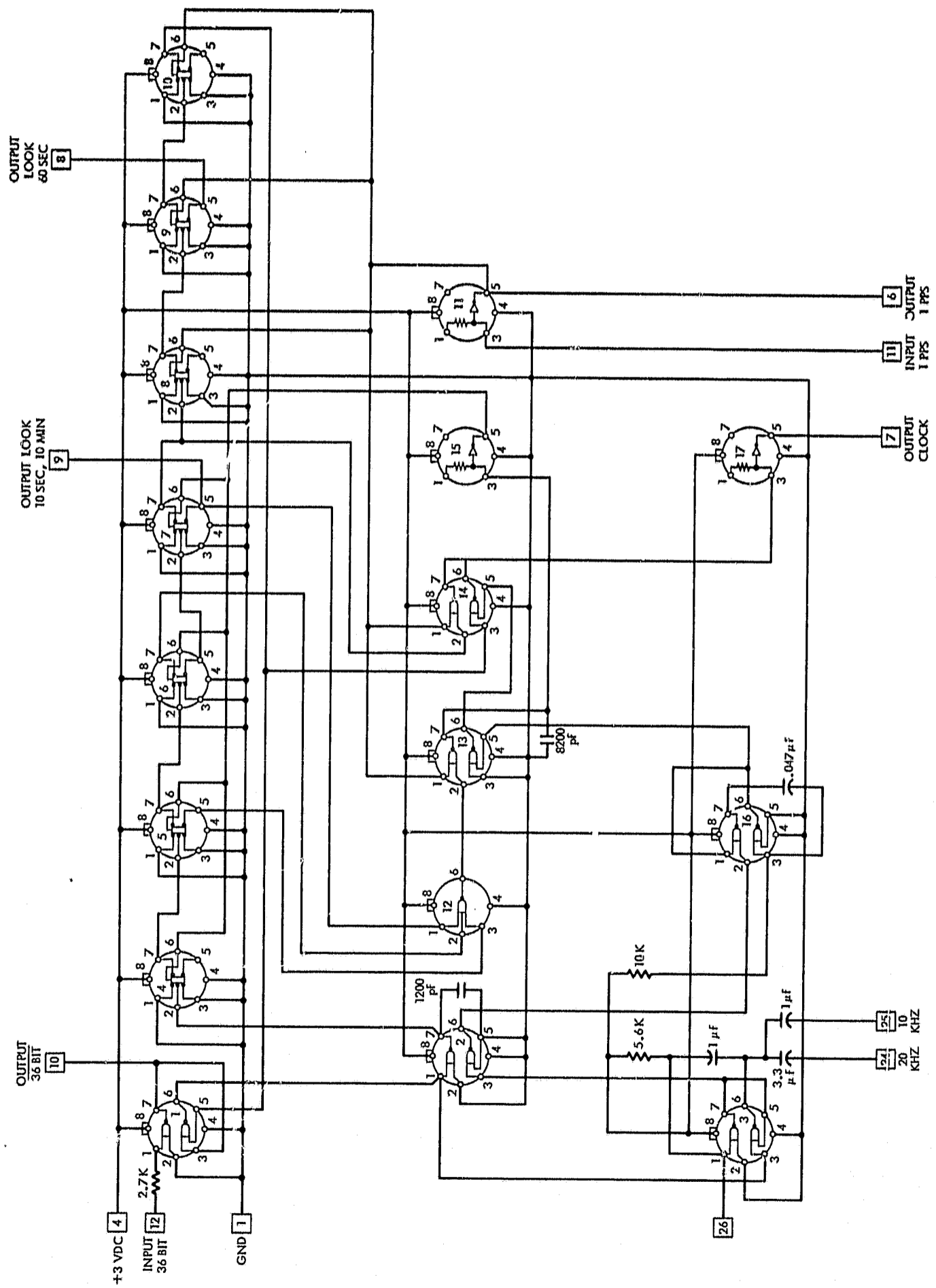


Figure 8. Card 2, Schematic Diagram

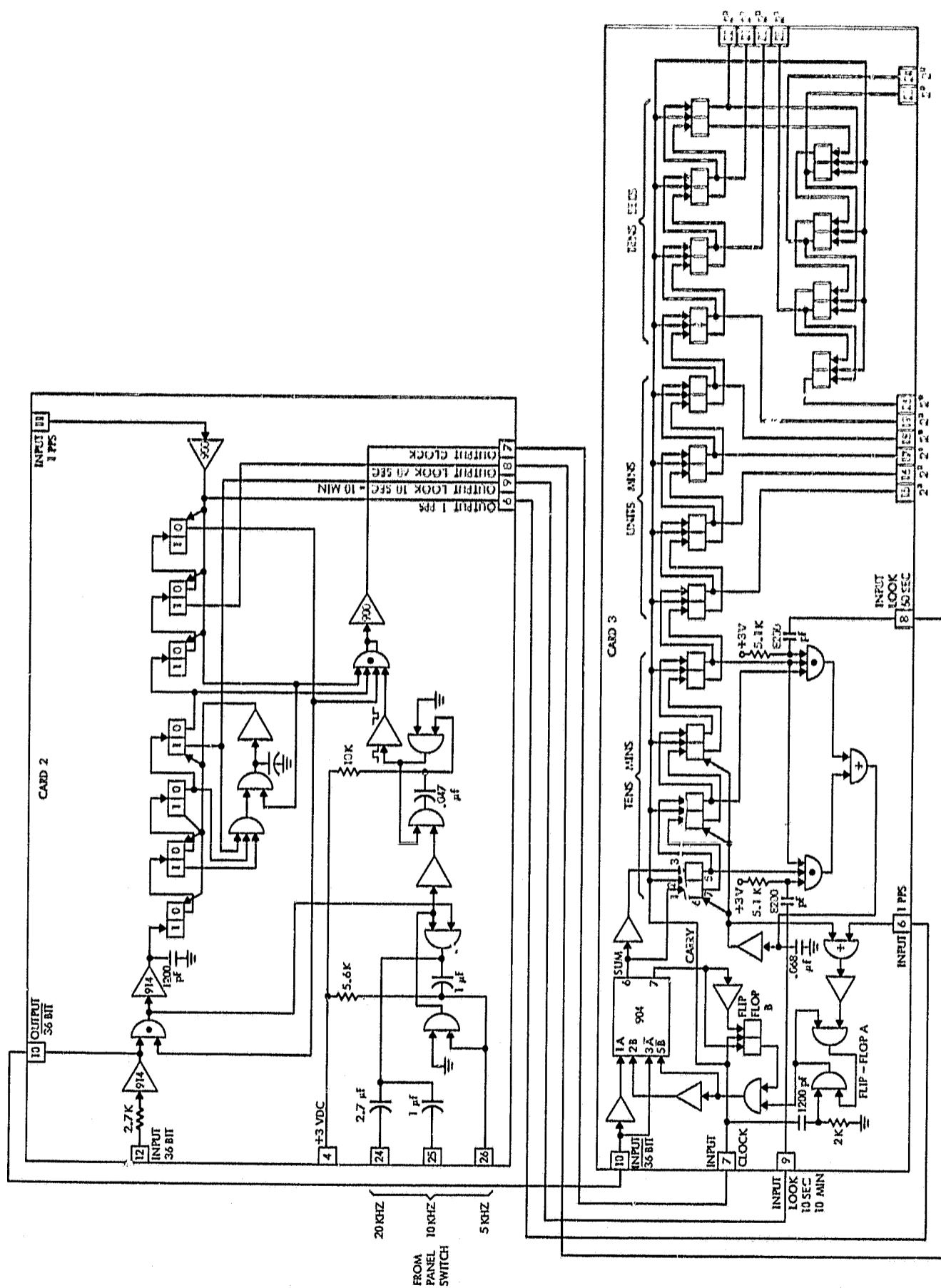


Figure 9. Cards 2 and 3, Logic Diagram

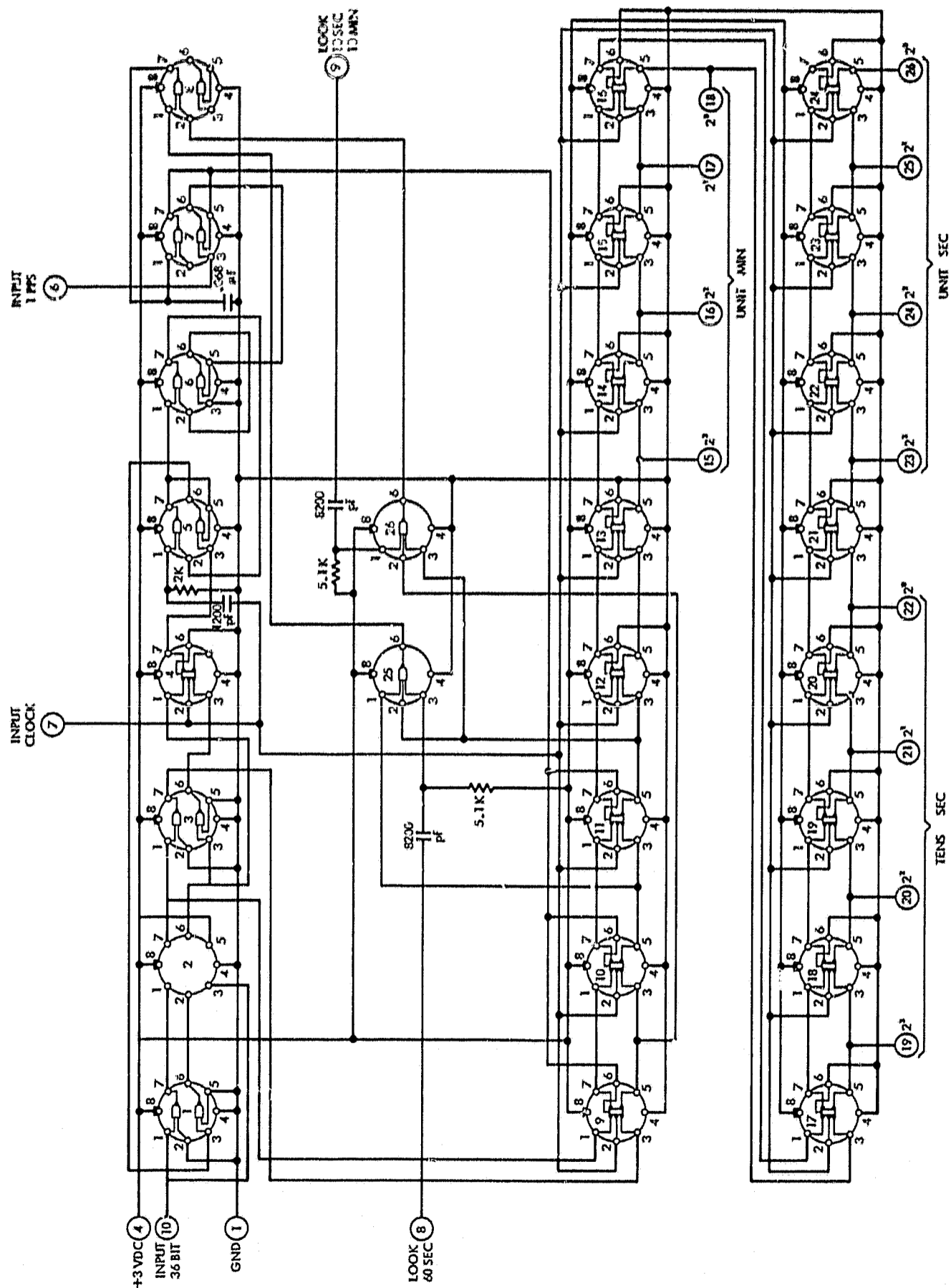


Figure 10. Card 3, Schematic Diagram

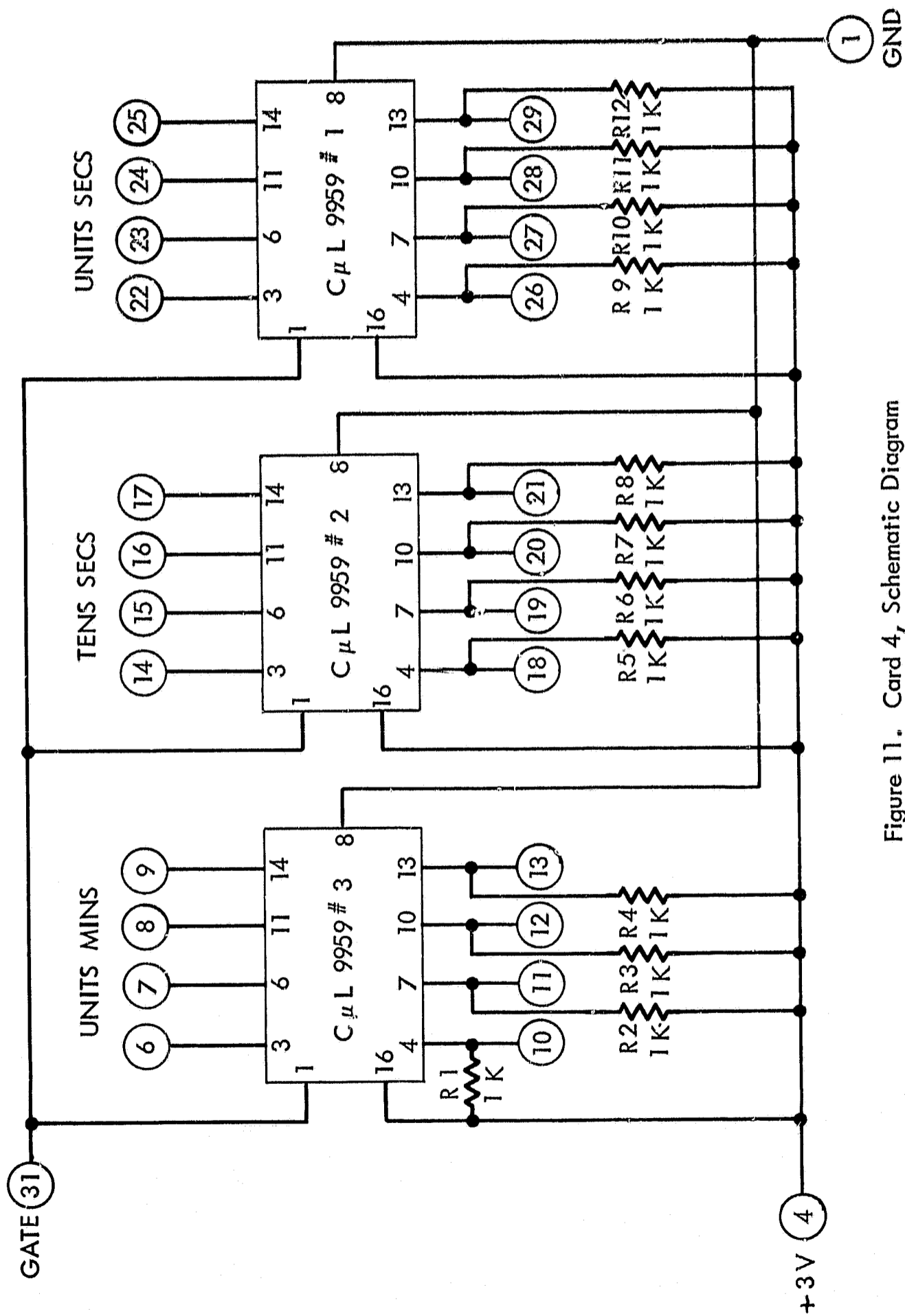


Figure 11. Card 4, Schematic Diagram

BCD TO DECIMAL DECODER, CARDS 5, 6, and 7. In these cards, input BCD information, at micrologic levels, is converted to decimal at 10-volt level. The information source can be the 36-bit memory or the PPM countdown clock, as controlled by relays. Decoder outputs drive the character generator.

A diode matrix is used to recognize the input combinations that are circled on Table 1. An output driver amplifier pair is driven by the matrix output resultant. An odd or even bus energizes only one side of the output driver amplifier, so only one side can go positive. This results in the correct number being presented to the character generator. A 4-pole, double-throw relay selects inputs from the correct source. See Table 1.

Table 1
Diode Matrix Combinations

Input Lines				Output
2^0	2^1	2^2	2^3	
0	0	0	0	0
1	0	0	0	1
0	1	0	0	2
1	1	0	0	3
0	0	1	0	4
1	0	1	0	5
0	1	1	0	6
1	1	1	0	7
0	0	0	1	8
1	0	0	1	9

Figure 12 is a simplified logic diagram, and Figure 13 is the schematic diagram of Cards 5, 6, and 7.

BCD - DECIMAL DECODER
CARDS 5, 6, 7

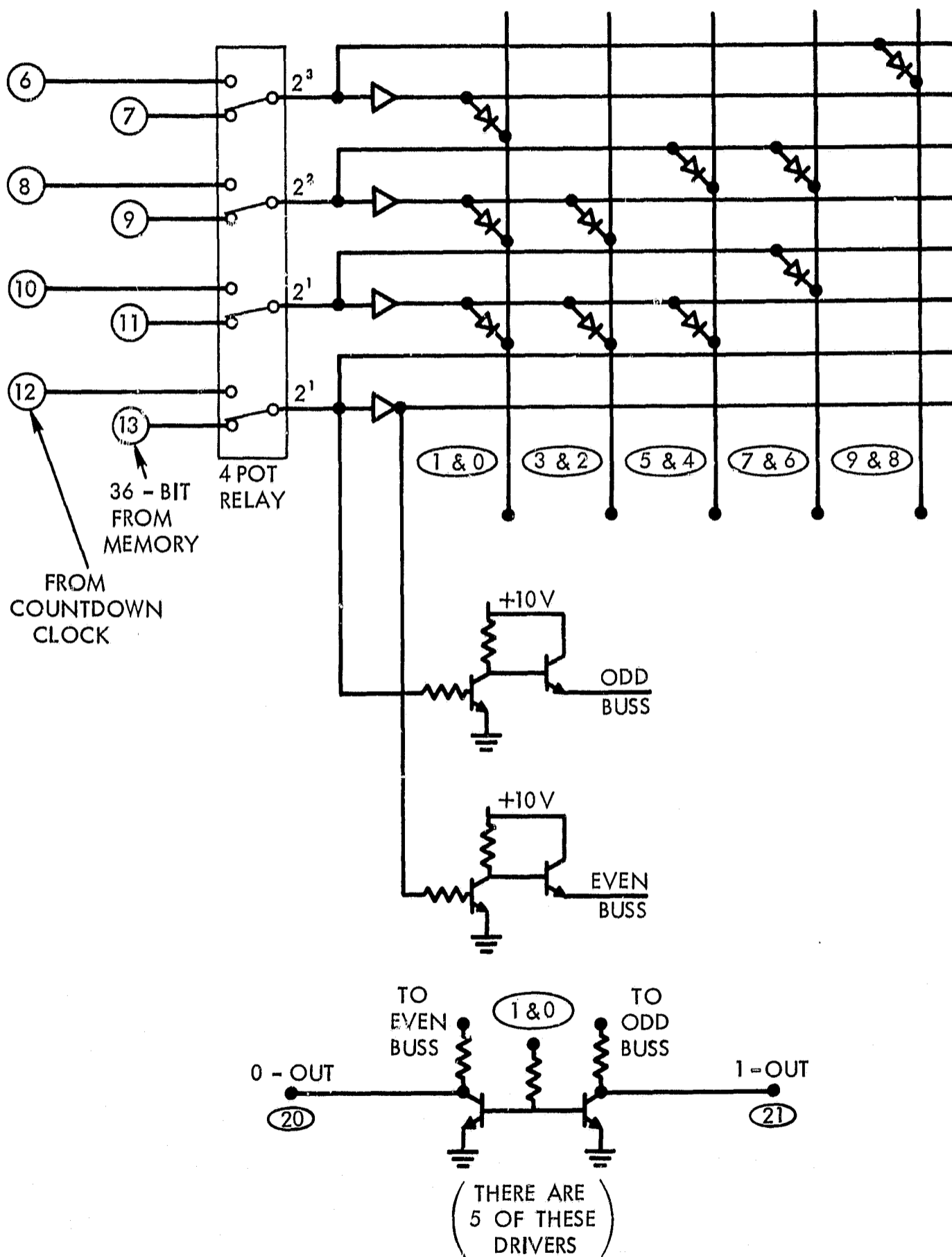


Figure 12. BCD to Decimal Decoder, Simplified Logic Diagram

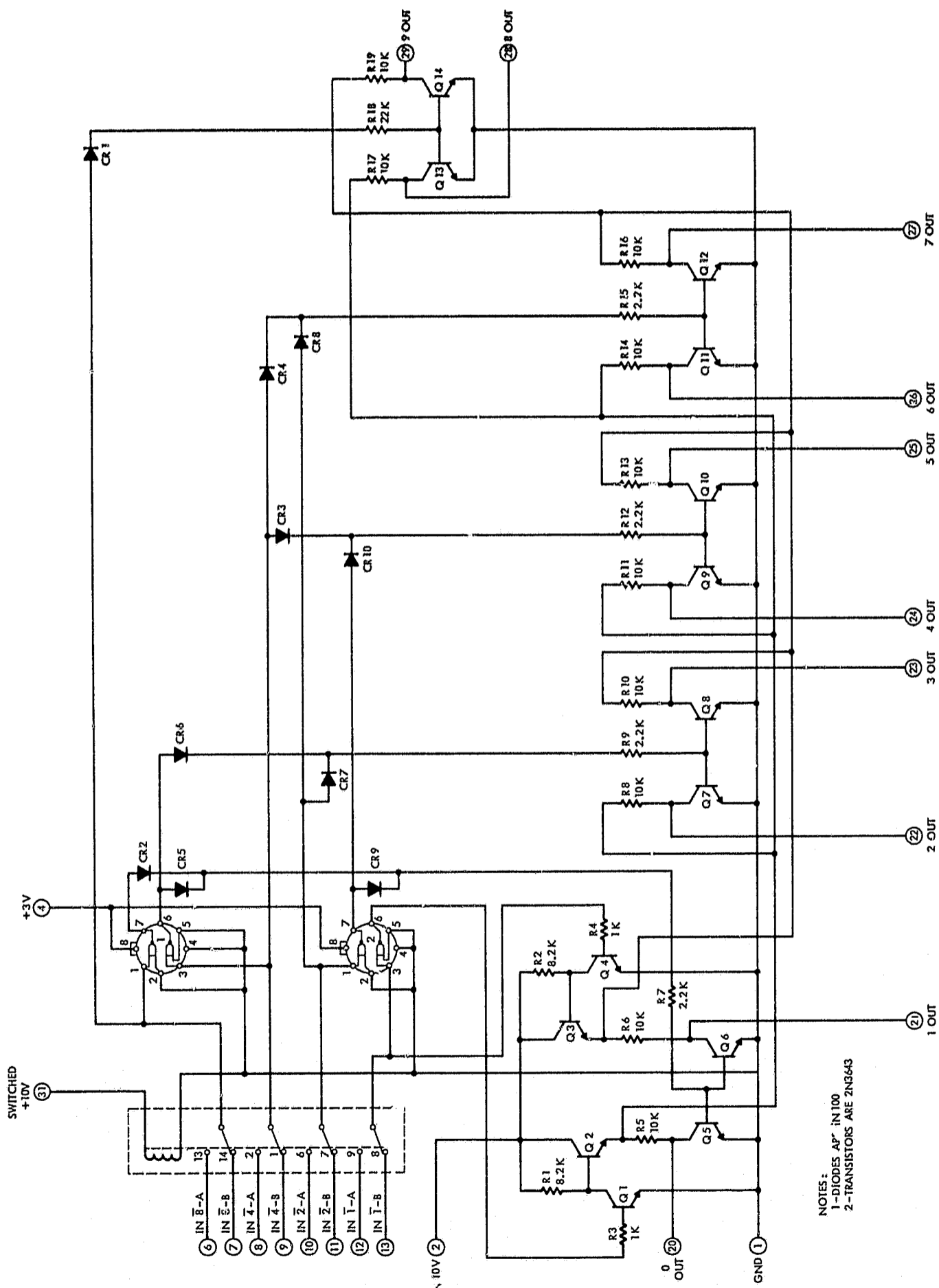


Figure 13. BCD to Decimal Decoder, Schematic Diagram

DATADIGIT CHARACTER GENERATOR

The Consolidated Electrodynamics Corporation DataDigit Character Generator provides signals necessary to drive the galvanometers of the oscillograph. Two galvanometers are used for each character to be printed.

This equipment must be properly set up before operating the system. Required procedures are in the CEC DataDigit Operation and Maintenance Manual. After adjustments are made, number size will remain constant if the paper speed switch setting on the character generator agrees with the speed setting of the oscillograph.

OPERATION

SET UP PROCEDURES

1. Ensure that the oscillograph (Honeywell Model 1612 Visicorder) is turned off and remove the cover of the lefthand (facing oscillograph) magnet bank assembly.
2. Remove the red and yellow cards.
3. On the red card, remove the four jumper wires that control galvanometers 1 through 4.
4. Replace these jumper wires with 82-ohm, 1/4-watt resistors.
5. On the yellow card, remove the two jumper wires that control galvanometers 5 and 6.
6. Replace these jumpers with 82-ohm, 1/4-watt resistors.
7. Replace the two cards in the magnet bank assembly.
8. Set up the oscillograph for operation (to allow sufficient warm-up time). Check that galvanometers 1 through 6, left bank facing oscillograph, are Type M-5000.
9. Set time printout control-unit source-select switch to COUNTDOWN CLOCK.
10. Set the character generator PAPER SPEED INCHES/SEC HEIGHT switch to a rate of 4 or 8.

11. Turn position potentiometers 1 and 2 on all mixer amplifiers (for galvanometers 1 through 6) fully counterclockwise. Then adjust position potentiometers 1 and 2, of mixer amplifier 1, four turns clockwise. This sets positions for galvanometers 1 and 2. Adjust position potentiometers 1 and 2, of mixer amplifier 2, six turns clockwise. This sets positions for galvanometers 3 and 4. Adjust position potentiometers 1 and 2, eight turns clockwise. This sets positions for galvanometers 5 and 6.
12. Turn width control potentiometers fully counterclockwise, for mixer amplifiers 1 through 6. Then turn both width control potentiometers clockwise $1/4$ to $1/2$ turn. This adjusts the width of the characters for galvanometers 1 and 2. Do the same for the other two mixer amplifiers.
13. Set the character generator SYNCHRONIZER B switch to TEST.
14. Manually position all galvanometers off the paper. Starting with galvanometer 1, manually position galvanometer 1 on the left edge of the paper record. Manually position galvanometer 2 so that 1 and 2 are superimposed. Position the remaining amplifiers so that galvanometers 3 and 4 are superimposed upon each other, and galvanometers 5 and 6 are superimposed upon each other.
15. Manually set the countdown clock to 888 seconds. This gives a continuous 888 out, enabling the operator to set up each galvanometer-pair superimposed, and correctly spaced between pairs.
16. Set the character generator PAPER SPEED INCHES/SEC HEIGHT switch to a low rate, matching the oscillograph speed.
17. Start the oscillograph, and check that the galvanometers produce sharply distinct 888's.

NORMAL OPERATION

1. Set up the oscillograph for operation (to allow sufficient warm-up time).
2. Set the character generator PAPER SPEED INCHES/SEC HEIGHT switch to match the desired paper speed set on the oscillograph. Set the SYNCHRONIZER B switch to NORMAL.
3. Set the time printout control-unit source-select switch to the desired source.

4. For real-time operations, set the time-printout control-unit frequency switch to 1/1.
5. For tape playbacks, set the frequency control switch at 1/1 for 5 kilohertz, 2/1 for 10 kilohertz, or 4/1 for 20 kilohertz.

NOTE

For all playbacks, the station clock frequency on the main patch and control panel is set at 5 KHz. For all tape playbacks, the time-printout control-unit source select switch must be in the 36 BIT position.

MAINTENANCE

The following instructions are applicable to the time printout control unit in particular. Complete maintenance instructions for the character generator are contained in the manufacturer's manual.

PREVENTIVE MAINTENANCE

Preventive maintenance consists of general cleaning and periodic visual inspection. Accumulations of dust, dirt, grit, and/or grease on circuit boards is harmful, and should be guarded against by periodic inspection and cleaning. Every three to six months, visually inspect the equipment for signs of deterioration, loose connections, security of mounting, and foreign matter. The frequency of cleaning depends on the particular operating environment and should be determined by visual inspection. As necessary, clean with a soft brush or low air pressure, being careful not to damage printed circuitry.

CORRECTIVE MAINTENANCE

Before attempting the repair of circuit boards suspected of malfunction, verify that the symptom is not caused by malfunction of associated equipment, such as the mounting case or inter-unit cabling. Once the existence of a defective circuit board has been established, visually inspect it for obviously damaged components, such as burned resistors. Next ensure that the correct operating power is being applied to the case and that the power supply potentials are correct.

Figures 14 and 15, the internal and external wiring diagrams, are provided for general troubleshooting reference.

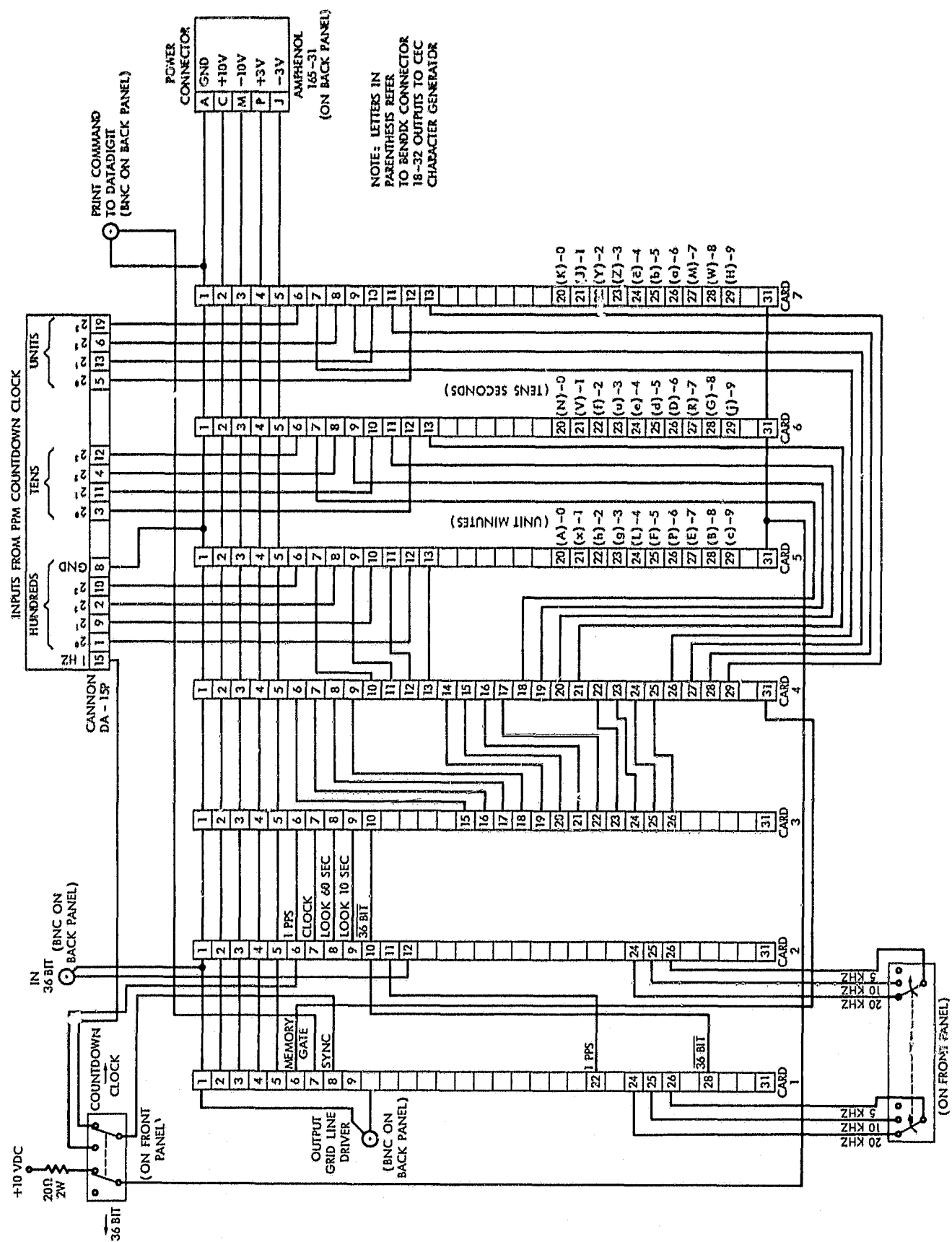


Figure 14. Wiring Diagram

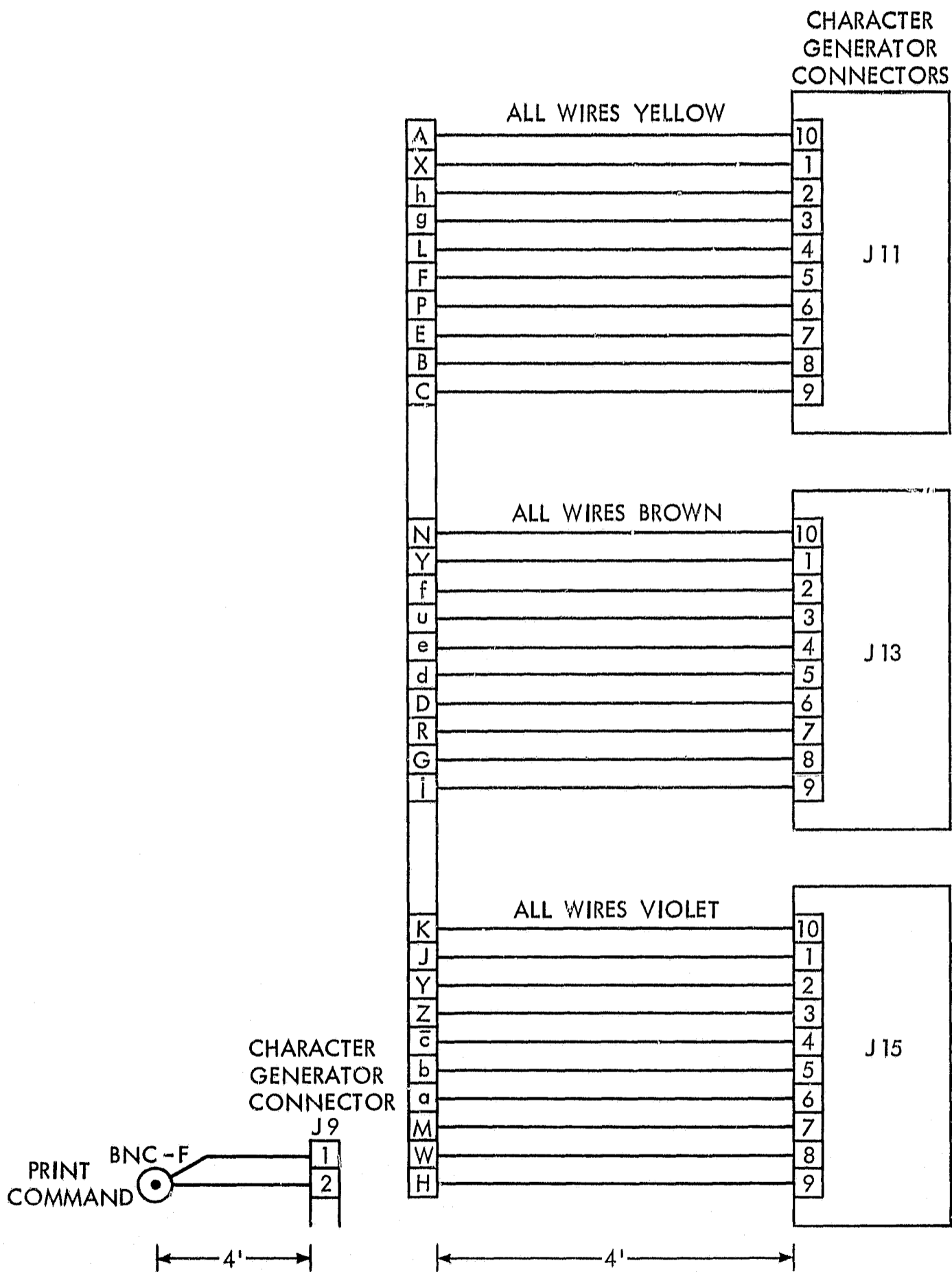


Figure 15. External Wiring Diagram